# FORENSIC MEDICINE

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## New medico-legal opportunities for recognition of a blunt object which caused deadly motor vehicle injury in wheel cross-moving

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Forensic-medical examination of injured car accident victim has a great relevance. Especially difficult is a car injury of wheel moving through the human body. In situations, where the driver was guilty, had left place of an accident and neither the trace from the tread nor side-surface of the tire tread were visually visible on the victim's body or clothing, the experts did not have sufficient reliable signs to determine a type and mass of the car. We assumed that, as a result of moving the car wheel, we'll observe on the victim body and clothing of specific elements from different kinds of rubber tier. We used spectral methods (XRF spectrometry and ESA). There is evidence discerned, that in the damaged part of the victim's body and clothing, there is a contamination — chemical elements of the rubber composition: zinc, iron, aluminum, calcium, silicon, magnesium and manganese because of the moving wheel of the car. In experiments with imitators of human tissues and clothing an amount of metal "transferred" to them from tires of an automobile or truck was established. An example of a practical application of the new knowledge is a commission forensic medical expertise.

*Keywords:* road crash from rolling a car, metals on the skin and clothing as a result of moving the wheel of the car, emission spectral analysis, commission forensic examination.

## Introduction

A damage caused by blunt objects for a long time has been and remains the most common type of mechanical trauma. They cause 45–80 % of cases of lethal injuries and in up to 87 % of cases — serious, although non-lethal ones [1; 2]. It should also be noted that the death rate of Russian citizens in road accidents is one of the highest among the all countries of Europe and North America [5].

In forensic medical practice, there are often cases of damage caused by items made of rubber (rubber sticks, shoes on rubber soles, rubber wheels of vehicles, etc.). The forensic medical experts may have difficulties in differential diagnosis of injuries with various blunt items, including those with a rubber follower surface. This happens because the traces of exposure to such objects on clothing and skin of the victims are non-specific, as well as the nature of injuries of internal organs and skeletal bones, thus making data uninformative and conclusions doubtful.

Previously, it was quite difficult for forensic experts to prove/establish the fact of contact between a blunt solid (hard) item (having rubber tracing or impacting surface) with a biological or non-biological object. For example, it refers to the tires of a car wheel when moving across the body of the victim (with or without a piece of clothing). However, in the composition of rubber there are metals (zinc, iron, magnesium, manganese, aluminum, nickel, calcium and non-metal silicon), whose oxides are used as catalysts in rubber manufacturing or pass into it from the composition of steel molds for casting these products. This information allowed us to put forth a scientific hypothesis about the transfer of chemical elements from one object (from the impacting surface of the trauma tool) onto another (to the area of traces — damages) and propose an opportunity for their detection.

Numerous experimental and expert studies have proven that the presence of chemical elements of the rubber composition found in the areas of traces and damages on biological or non-biological objects is an indisputable fact confirming that the impact of a trauma object made of rubber [3; 4]. The presence of these chemical elements in the area of tracks (in particular, wheel protectors) and damages is established by spectral methods of research (X-ray fluorescence and quartz spectrometry by certified methods).

## Purpose of the study

To prove (during the forensic medical expertise of car injuries from moving the wheel across the victim's body and/or clothing) the transfer of the chemical elements (constituents the rubber) from the tread onto the area of traces and damages, as well as the possibility of detecting them for a differential diagnosis of the injury.

## Material and methods

*First,* we carried out an analysis of forensic documents (acts of corpse investigation and expert opinions in cases of fatal car injuries) issued by the Bureau of Forensic Medical Expertise of a large city in the North-West Federal District of Russia in 2009 (594 cases) and in 2010 (407 cases), totally 1001 cases in 2 years.

*Second,* we performed forensic medical experiments. The objects of the study were various models of domestic and foreign tires of trucks and cars. For the experiments we

used various models of radial non-studded automobile tires with a width of the running surface of the tread between 165 and 205 mm, with / without signs of wear of the rubber. We also studied samples of the traces left by surfaces of these objects: their contactograms, spectrograms, X-ray traces of damage, micro-particles of rubber introduced into the traces on damaged area.

During the experiments, we got traces of the tread when rolling (moving) different wheels of a truck and a car across a simulator of human hip with attached clothing fabrics and skin grafts taken from corpse. We have received the permission of the Ethical Committee of the Clinical Hospital no. 122 to conduct research with biological material. Cars had a mass of about 900 kg, unloaded cargo tracks — 3750 kg, loaded ones — 6500 kg.

We also examined traces of damage from the impact of the wheel tread on the biological (skin of 20 bio-dummies) and non-biological (cotton fabrics of clothes of light and dark colors) objects. We studied the traces of damages on the objects by various methods: visual inspection, morphometric studies, direct stereomicroscopy with biological stereomicroscope "MBS-10", Lytkarino Factory of Optic Glasses, Russia), photography, in ultraviolet and infrared rays, radiography, contact-diffusion, various kinds of spectroscopy (X-ray fluorescence spectrometry, emission spectral analysis), with subsequent comparative and mathematical statistical data analysis. X-ray spectral analysis was carried out on a crystal-diffraction analyzer "Spectroscan LF" ("NPO Spektr", St. Petersburg, Russia). This device allows to determine more than 70 chemical elements, with a small own instrumental error (<0.5 %) and high sensitivity (0.0001–0.001 %). These features make it possible to use it effectively for solving analytical problems related to wide range of chemical elements. Usage of emission spectral analysis (ESA) was selected due to its greater sensitivity compared to X-ray fluorescence (XRF) analysis.

*Third* component of this study was a forensic medical commission expertise of the criminal case, carried out by the authors of the article with the application of new method. The objects of expert evaluation were all the materials of the criminal case, including the results of corpse autopsy, data of forensic histological, chemical and biological investigations. In addition, we conducted a forensic medical-criminological examination of a material evidence in the case — the clothes of the victim (T-shirt). On the conduct of this examination, a decision was issued by the investigator, in which he indicated that the victim was wearing this T-shirt at the time of the probable alleged drive of the car's wheels across his body.

## Results and discussion

An analysis of forensic-medical documents drown up for the victims of car injuries showed that in 80 cases (8 %) the type of injury was the moving (rolling) of the car wheel across the victim's body. The most frequent area of rolling was the chest of a victim (37.5 % of cases in 2009, 75 % in 2010). In none of the analyzed cases did the forensic medical experts determine the type of the vehicle (cargo truck, passenger car) and its weight, although law enforcement officers asked these questions.

In experimental studies with imitating objects, we detected differential diagnostic sings of injuries and traces on clothing fabrics (white and dark color), formed as a result of rolling (moving) the car wheel across them. The shape of the impact partially represented the elements of the tire tread in the form of strips or strokes. The width of the

strip-shaped traces of the tread was from 13 to 18 cm. In rare cases, the fabric had linear macro-lesions with uneven edges, the lengths of which often were perpendicular to the direction of wheel movement. By means of stereomicroscopy of experimental tread marks on clothes (T-shirts) we detected micro-damages in the form of crushing or compression of the fabric system fibers, sometimes — confusion of the fibers.

The chemical elements of rubber tires (zinc, iron, aluminum, calcium, silicon, magnesium and manganese) were transferred to biological (skin) and non- biological (white either black/dark color fabrics) objects, when rolling the wheels of different cars. Studying the experimental tracks of the tread on cotton clothes, we discovered introduced chemical elements (in particular, zinc and iron in various amounts), inherent in the composition of rubber tires of vehicles. The amount of zinc and iron contained in the impacts of different tires on clothes (Table 1) is useful for differential diagnosis and for an answer to questions of the investigator about the type of vehicle and its mass.

*Table 1.* **The average relative amounts of zinc and iron in the tracks of tires from the protectors of wheels of vehicles on clothes made of cotton fabric (of white either black/dark colors)**

| Experiment # | Investigation subjects | Chemical elements, M±m, impulses/100 sec | |
|---|---|---|---|
| | | Zn, spectrum line 1436 мА | Fe, spectrum line 1938 мА |
| 1 | Trail of domestic car wheels on white cotton fabric | 94 ±26 | 287 ± 50 |
| 2 | Trail of foreign car wheels on white cotton fabric | 71 ± 20 | 154 ±36 |
| 3 | Trail of domestic truck wheels on white cotton fabric | 364 ± 38 | 630 ± 49 |
| 4 | Trail of foreign truck wheels on white cotton fabric | 313 ± 35 | 1071 ± 65 |
| 5 | Control sample of white cotton fabric | 31 ± 17 | 89 ± 28 |
| 6 | Trail of domestic car wheels on black cotton fabric | 96 ± 24 | 293 ±50 |
| 7 | Trail of foreign car wheels on black cotton fabric | 85 ± 22 | 223 ± 43 |
| 8 | Trail of domestic truck wheels on black cotton fabric | 117 ± 21 | 144 ± 24 |
| 9 | Trail of foreign truck wheels on black cotton fabric | 130 ±22 | 146 ± 24 |
| 10 | Control sample of a black cotton fabric | 42 ± 19 | 63 ±23 |

As an example of using the experimental data obtained, we cite a case from our forensic expert practice. We performed a forensic medical commission expertise. The materials of the criminal case contained information that at night a dead body of a Mr. K. was found in the courtyard of a residential building in one of the major cities of Russia. Next to the corpse the investigator found a fragment of a wooden board 16 cm wide, 56 cm long and 4 cm thick, weighing 2.7 kg, with brown spots, similar to blood. The forensic medical expert made a primary examination of the corpse. Visually the expert revealed

a bruise on a skin of the corpse, localized in parieto-occipital area of a head and in the right shoulder area of a back. The form of the bruise was strip-shaped, it had an oblique-vertical direction, cyanotic color, measuring 16×23.5 cm. The forensic medical expert identified a second band-shaped bruise, located on the skin of the abdomen and chest, on the right (at the site of the projection of the liver), located almost horizontally, measuring 18×21 cm. During the internal examination of the corpse, the expert has not detected any injuries of the cranial bones, brain tissue, and meninges. He revealed direct fractures of VIII–XII right ribs along the anterior, middle and posterior axillary lines; multiple liver ruptures of various depths, partial destruction of hepatic tissue with complete separation of its lobes; rupture of the small intestine; hemorrhage in diaphragm. About 2.5 liters of blood was in the abdominal cavity. Also autopsy revealed hemorrhage under the endocardium of the left heart ventricle and desolation of blood vessels with ischemia of internal organs. Mr K's death resulted from a closed blunt abdominal and chest traumas with gross liver damage, multiple fractures of the ribs, complicated by severe massive blood loss.

The investigator established a witness of the incident, who saw from the window of his apartment two men who had just left the food store and were in alcoholic intoxication. They began to quarrel and swear. One of the men (Mr. D.) took a piece of a wooden board lying on the lawn and inflicted several blows on the back and head of the victim (Mr. K.). The victim fell to the asphalt, and attacker disappeared from the place of incident. The witness called the police and ambulance. He did not approach to the window anymore. The ambulance doctor ascertained death of the victim at the scene of the incident.

The forensic medical expert made a primary examination of the corpse, concluded that all lesions belong to blunt trauma, and could have been caused because of very strong impacts by the board found at the scene. Expert substantiated this conclusion by the nature of the damages detected; by available at that time materials of the criminal case; by the results of forensic biological investigation (detection of the blood of the deceased on the weapon of injury — the wooden board). The attacker (Mr. D.) was charged with premeditated murder. During the judicial investigation, the defendant confirmed the fact of striking the head and back of the victim; however, he categorically denied blows in the abdomen. In criminal case materials there were reports that the courtyard in which the corpse of Mr. K. was found had an exit on the street. Several witnesses (the residents of the house) saw a motor vehicle passing through the courtyard and/or heard the sound of the engine from the moment of the men's fight before the arrival of police and ambulance. In addition, the nature and extent of liver and rib lesions testified to the action of a massive blunt object. The court, at the request of the lawyer, decided to appoint a forensic medical commission expertise, as well as medical criminological examination of the victim's clothing. On the brown cotton T-shirt no macro-damages was found. However, the experts found the contamination on the front surface of the T-shirt in the lower right part in a section measuring 16×20 cm in the form of indistinctly distinguishable dark gray traces of an indeterminate shape. Experts found zinc and iron in these tracks using the method of X-ray fluorescence spectrometry (XRF). The quantitative content of these metals was statistically significantly ($P<0, 05$) higher than in the control sample (Table 2).

In subsequent studies, experts found that in the traces on the T-shirt, along with zinc and iron, there were other chemical elements, typical constituents of tires' rubber. Experts used the method of emission spectral analysis and found statistically significant (Student's

*Table 2.* **The relative content of zinc and iron in the trails on the fabric of the T-shirt and in the control sample, revealed by the XRF method**

| Measurement | Objects of investigation | Chemical elements, M±m, impulses/100 sec | |
|---|---|---|---|
| | | Zn, spectral line 1436 мА | Fe, spectral line 1938 мА |
| 1 | The area of contamination traces (trails) on the fabric | 181 ± 32 | 187 ±33 |
| 2 | Control clean area of the same fabric | 71 ± 17 | 90 ± 19 |

t-criterion >3) increase of magnesium content (t = 12.1), manganese content (t = 5.1), and aluminum content (T = 8.5) — all compared to the control sample.

Thus, the results of spectral studies made it possible to prove the fact of contact of the T-shirt fabric with a rubber-made object, since the chemical elements found in the tracks on the T-shirt were peculiar to the composition of the rubber.

The forensic medical expert commission carried out an analysis of the new data of forensic medical and criminalistics investigations, the results of the forensic medical examination of the corpse, additional data on the circumstances of the case, and formulated the conclusion.

In the conclusions, experts argued that the fractures of the VIII–XII right ribs along all the axillary lines, the partition of the liver into lobes, its extension and ruptures and other injuries were caused to the Mr. K. by the action of a massive blunt item with a rubber trailing surface. The item acted on the abdomen and thoracic area from the right side. These damages could not be caused by a wooden board, which could cause damage from behind, not causing death. Severe massive liver damage and others, complicated by acute blood loss and leading to the death of the victim, could have resulted from partial rolling of the vehicle's wheel across the victim's abdomen and the lower lateral part of the chest. Finally, the law enforcement agencies identified a car, a driver of which rolled over the body of Mr. K.

## Conclusions

1. It has been proven that in the case of a fatal motor vehicle accident with wheel rolling across a victim, traces (impacts) remaining on the damaged part(s) of the body and/or clothing of the injured person contained chemical elements characteristic of the composition of rubber of vehicle tires.
2. Spectral methods of investigation (X-ray fluorescence spectrometry, emission-spectral analysis) allow detection of the introduced contaminating chemical elements of the rubber composition (zinc, iron, aluminum, calcium, silicon, magnesium and manganese) on biological and non- biological objects damaged by rubber items.
3. It was shown experimentally that the relative average quantities of zinc and iron detected on white and dark cotton cloth differ in traces, left by the wheels of either a car, or a truck. There is also some difference in metal contamination depending on origin of tires' rubber.
4. The obtained data significantly increase the effectiveness of forensic identification of the instrument of trauma — as regards to recognition of the type and origin of a blunt damaging item (e.g. made from rubber).

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